Applications of SEM Technology

Ron Rasch – UQ Lab manager
Battery technology:
Making smaller and lighter batteries, that are much more energy dense. This is for stuff like electric cars etc. Energy density is the key concept here, a typical car battery (lead acid) may weigh 15 to 20 kg, run an electric car on that and you don't get far, maybe just out of the city if you are lucky. Run a petrol car on 20kg of fuel and you would travel 250 to 300 km. So making batteries that store more energy for less weight is critical. SEM and EDS investigation of the microstructure as the battery is energy cycled is key here.

Metallurgy Corrosion:
Right now I have two metallurgists doing SEM and EDS, one is looking at the corrosion effects to make steel rust less and the best methods of protection

Metallurgy Mechanical design/Fuel economy:
The other is looking at bearing wear and lubrication greases to understand how engines wear out and how to make them last longer. The development of new lubricants is the silent partner to making more fuel efficient cars. In the old days to protect an engine, you used thick oil. But thick oil causes more viscous drag, and uses more fuel. An 5W30 ILSAC GF-5 (resource conserving) oil (or better), which is now pretty much standard issue in any new car sold in North America, offers a 2.5% fuel economy improvement over an old school 15W40 heavy duty engine oil. These thinner oils swap hydrodynamic protection for less viscous drag, so the additive pack (anti-wear agents added to the oil) need to be developed to get that wear resistance back. In 2014 there were 17.5 million new cars/truck sold in the USA, multiply that by a few % fuel saving, big numbers.

Exploration geology:
SEM & EDS plays a critical part in geologists deciding where mining should take place, the ability to analyse the rocks for total metal content, and see in which form the desired metal is bound (eg Sulphide vs Silicate) is important to understand the economic viability of a potential mineral deposit.

Sedimentation geology:
Some Geo's look at the sediment record for evidence of past catastrophic geological events, such as Tsunami or earth quake. The evidence is marine micro-fossils found as part of inland sediments. In Germany, the nuclear power stations are built to withstand the largest earth quake on human record in the area, however it's been argued that the largest earth quakes the area has experienced are significantly more powerful than this human record, according to the geological record. In the Japanese Fukushima nuclear disaster, they had built a 10m protective seawall, but the Tsunami was 13m high.

Kim Sewell – UQ Lab Manager

Nacre (from abalone):

The strength of the layered CaCO3 chalk plate structure versus "blackboard" chalk and discussions of crack propagation; the mother of pearl colours resulting from the interaction of the near light wavelength size of the layers i.e. colour not provided by pigment e.g. diochroic glass. Can lead into functional morphology discussion (why does an abalone shell need to be strong) biomimicry discussions e.g. Kevlar vest structure.

Gecko feet (Asian Barking Gecko):

The finely divided spatulae and the incredibly strong attachment provided by multiplying weak electrostatic forces (Van der Waals force); Leads into biomimicry discussions e.g. gecko tape etc. Functional morphology discussions e.g. how do geckos remove the attachment. How can they still run fast? What surfaces can geckos not stick on. Can lead into discussion about introduced species and how to prevent and control them as well as ecological considerations.

Fire Ants:

Taxonomic characters unique thorax morphology (double "bump"); sting (modified ovipositor) mandibles etc. Ants are sometimes described taxonomically by just a string of numbers coding for various taxonomic characters. Can discuss differences between workers queen etc. Can lead into discussion about introduced species and the logistics, method and success of the Fire Ant program in Queensland.

Bees:

European and native examples. Taxonomic structures. Functional morphology e.g. pollen baskets, scopeae, hairs. Threats to honey industry e.g. hive beetle and possible controls e.g. diatomaceous earth at entrance. Can lead into broader discussions about the honey industry e.g. Manuka (Tea Tree) Honey from New Zealand, Queen Bee jelly, antibiotics etc.

Pollen

Extant and fossil specimens. Intricate taxonomic structures that can be used to discriminate living and ancient extinct species. The use of pollen in forensic science e.g. Lynn Milne http://www.abc.net.au/austory/9169418 solved a north coast murder story on the basis of pollen on clothing.

Bronwen Cribb – UQ/Qld Museum

- Anti and super-wetting
- Changes in fluid flow across surfaces, and control of directional flow
- Antimicrobial properties that result in killing (tearing apart) of pathogenic bacteria
- Substrate modification in the micro and nano range that encourage growth of cells where they are wanted, such as on certain prostheses
- Changes in adhesion to surfaces
- Changes in colour
- Use of micro and nano porosity to trap wavelengths for example for heating
- Sandwiched structures that generate electrical current in for example some wasps, as a morning kick-start